Determination of Rain Cell Size Distribution for Microwave Link Design in Malaysia

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Abstract--In designing or planning for a microwave link, attenuation due to rain is often a major obstacle to overcome. Sometimes, mitigation technique such as space diversity is also considered. However, a rain event occurring in an area is not constant. Rain does not distribute evenly in a region experiencing precipitation. This is especially true in tropical regions as rain has been found to be more convective in nature rather than widespread. Tropical region also suffers heavier rainfall rates as compared to temperate regions. Important information are rain cell size and rain distribution inside a cell. Results from this study confirmed that rain cell in Malaysia is highly convective and a rain cell with a center rainfall rate of 120 mm/hr will have a diameter of about 1.2-1.5 km

1. Introduction

Microwave link is very important in radio communication systems. For good engineering and economic practice, it is always desirable to reduce the cost of a system and avoid interference to other radio systems. However, the major concern in microwave link design is the attenuation due to rain.

Tropical countries, like Malaysia experience very high rain rate during the monsoon seasons. One mitigation technique is site diversity [1]. In this technique, the system uses two receivers. If either one suffers heavy attenuation, then the one with the lesser attenuation will be utilized. Data processing will also enable for the two receivers to be utilized for the best reception. An important parameter for site diversity is the separation between the two receivers. This can be determined by knowing the rain cell size distribution. Thus, the purpose of this paper is to determine the rain cell size distribution for the local environment and to study the rain distribution inside a rain cell.

2. Experimental Set-up

A network of four rain gauges was installed in the UTM, Skudai campus. These rain gauges are Casella Tipping Bucket Rain Gauge with Integral Logger. Four locations were chosen, the first one being near the Faculty of Chemical Engineering (Chemical Station). Except for the Chemical Station, which has a 0.2 mm tipping bucket, the rest have 0.5 mm tipping bucket, and all gauges have a 1-minute integration time. The rest of the stations are Institut Voltan dan Arus Tinggi (IVAT Station), TV Studio Station, and the Kempas Station.

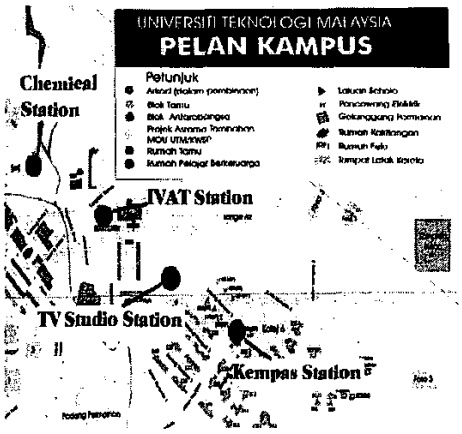

Figure 1. Rain gauge network stations

The rain gauges were installed such that the distances between them are about 250 meters, forming an almost straight line. All the rain gauges were synchronized using the same notebook

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computer. The locations of the rain gauges are as shown in Figure 1. The network was set-up in December 1998. Data were available until July 1999.

3. Data Analysis

3.1 Rain rate distributions

Figure 2 shows the rain rate distributions for all the rain gauge stations. The Chemical Station uses a 2 mm buckets and was better in measuring lower rainfall rate. However, readings at higher rainfall rate are similar for all the stations.

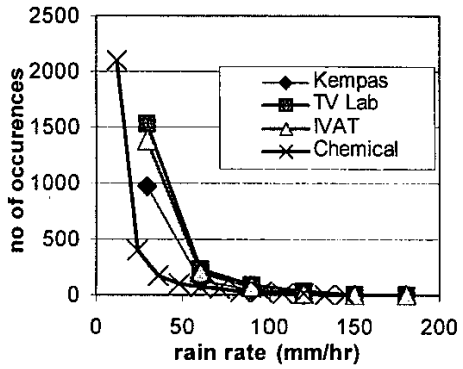

Figure 2. Rain rate distribution at rain gauge stations

3.2 Rain rate for 0.01% of the time ($R_{0.01}$)

An important parameter in rain attenuation studies is the rain rate for 0.01% of the time or $R_{0.01}$. The $R_{0.01}$ values for all the stations are given in Table 1. Also given in Table 1 are the $R_{0.01}$ values from the Meteorological Department in Johor [2] and ITU-R [3].

Table 1. $R_{0.01}$ values for all the rain gauge stations

Rain Gauge Station	$R_{0.01}$ value
Chemical	128 mm/hr
IVAT	119 mm/hr
TV Studio	120 mm/hr
Kempas	107 mm/hr
Johor Bahru	120 mm/hr
ITU-R	120 mm/hr

The $R_{0.01}$ values for all the stations were comparable the values obtained from the Meteorological Department which is a long-term measurement and the value from ITU-R. Averaged value for all four stations is 118.5 mm/hr.

3.3 Data selection

For the purpose of this project, not all data collected were utilized. In accordance to the value of $R_{0.01}$ of 120 mm/hr, simultaneous readings at all stations in which the IVAT Station and the TV Studio Station recorded readings of rain rate of 120 mm/hr were selected. Using these selected data, it is assumed that the center of the rain cell will be either at the IVAT Station or TV Studio Station. All the readings are averaged and these values are given in Table 2. The data are plotted in Figure 3. The curve fit lines were obtained using linear least squares method.

Table 2. Simultaneous rain rate readings at all stations when IVAT registers 120 mm/hr rain rate.

	Averaged Rain Rate (mm/hr) for each Rain Gauge Stations			
	Chemical	IVAT	TV Studio	Kempas
120 mm/hr at IVAT	77	120	77.5	67.5
120 mm/hr at TV Studio	64	100	120	70
Average	70.5	110	98.75	68.75

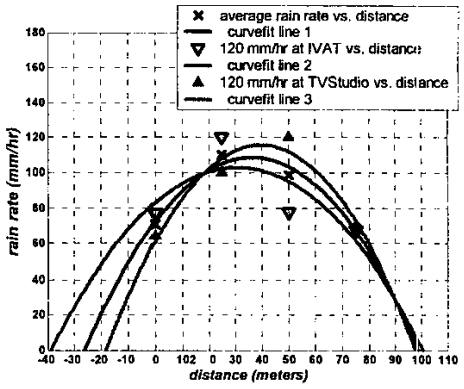

Figure 3. Averaged rain cell size

4. Rain Cell Size and Intensity Distribution

From the curve fit lines it can be seen that the rain events were highly convective. The center of the rain cell experienced a heavy rainfall while the rain rate tapers rather rapidly toward the edge. The averaged rain cell is about 1.25 km. It can be safely assumed that the rain cell size is between 1.2 km to 1.5 km. This result agrees with previously published result [4].

5. Conclusion

This study has found the rain cell size that can be used for microwave link design especially in the application of site diversity. It agrees very well with previous results. This study also confirmed the $R_{0.01}$ to be used in future studies.

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